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#5-143 Rising Edge Pulse Shape Discrimination in Ultrathin YAG:Ce Scintillators

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Detecting and discriminating heavy charged particles from background radiation at high temperatures is of interest for nuclear applications, including basic research in fusion and fission energy, reactor monitoring, fuel reprocessing, and isotope production. We investigated the detection and discrimination between alpha and beta particles compatible with liquid environments, significantly above room temperature (>90℃). Yttrium aluminum garnet doped with cerium (YAG:Ce) is a scintillator that has the advantages of being non-hygroscopic and chemically inert. YAG:Ce has a relatively high light output, about 20 000 photons per MeV of deposited electron energy. Its emission spectrum peaks at 525 nm, which matches the transmission spectrum of the electrolyte solution where it is intended to operate in our application. By using an ultrathin (30 µm) crystal, sensitivity to gamma rays and X-rays can be minimized, such that charged particles can be detected with high specificity. In the experiment, we used a CAEN DT5730S digitizer to record detailed waveforms from YAG:Ce exposed to various radiation sources. Pulse shape discrimination (PSD) capabilities of YAG:Ce are well-documented using the traditional metric relying on the falling edge of the scintillation time profile. While processing the calibration data acquired with alpha sources (241Am and 210Po) and beta sources (90Sr and 204Tl), we observed significant differences in the rising edge of scintillation pulses. This dependence of rise time on the charged particle stopping power could lead to improvements in particle identification. Additionally, preliminary measurements suggest a sensitivity of the time profile of scintillation emission to the energy deposited by beta particles. A mechanism for this may be the significant difference in average stopping power for beta particles of different energy in thin crystals, but more detailed measurements are needed to investigate this effect. Future measurements should also be sensitive to the known dependence of the scintillation spectrum of Ce:YAG on the charged particle stopping power.
Depending on the particle identification performance obtained from the combination of the rising and falling edges of the scintillation time profile, it may be possible to implement YAG:Ce as a "monolithic phoswich" detector. Other potential applications of such a detector include decommissioning of nuclear power plants and gas enrichment plants, online monitoring of the uranium content extracted from the ground, and space exploration.

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